Then on the last line on page 404 we read that the movement is 46″ and the rotation is accomplished in 2,800,000 years.

Here is a contradiction which would puzzle your readers and I owe you an explanation.

The number 48″ is the result of my personal calculations, and 46″ is that given by the *Annuaire du Bureau des Longitudes* at Paris. The two computations differ by the insignificant amount of 2″. When I speak of my personal work I use my own figures. Under other circumstances I purposely employ the figures which have been scientifically approved.

Moreover, I was formerly in agreement with the Bureau of Longitude who then indicated 48″, but the Bureau has changed its computations and now gives a velocity of 46″.

If I had thought that the two contradictory figures would be used side by side, I would have made them consistent.

PIERRE BEZIAU.

PARIS, FRANCE.

"THE THIRD MOVEMENT OF THE EARTH."

To the Editor of The Monist:

The article appearing in *The Monist* of July, 1908, under the above quoted head, by Pierre Beziau is interesting from a certain standpoint and ingenious; but the author is handicapped in not being familiar with the mathematics of astronomy, and, we may add, with descriptive astronomy. If the matter had been as simple as M. Beziau seems to think, the labors of La Place, Le Verrier, Adams, and a host of other mathematical astronomers would have been rendered useless. The law of gravitation (which is that every particle in the universe attracts every other particle with a force varying directly as the sum of the masses of the two particles and inversely as the square of their distances apart) is the proximate cause of a wonderful complexity in the motions of the heavenly bodies. It has required the combined energy, skill, and genius of mathematicians extending over three centuries or more of time to reduce the apparent irregularities of motions of the heavenly bodies to regularity. The most refractory of all has been our nearest neighbor, the moon. She has up to the present moment successfully defied them all. She has yet a small irregularity which is a bone of contention among astronomers. Some say this irregularity is accounted for by the slight retardation of the earth's rotation on her

axis during the ages, due to tidal friction. Others say, "No. A part of this irregularity can be so accounted for, but not all." But for the most part the motions of the heavenly bodies constitute a solved problem; or, perhaps we should say, a series of solved problems.

M. Beziau's third motion is the present slow change in the obliquity of the ecliptic (the path of the sun's apparent motion among the stars, the real path of the earth, regarding the sun as fixed in space). He gives this change as 46″ per century, given as 45½″ per century by some authorities. Now, if this change were constant, the time would come when the axis of the earth's rotation would become perpendicular to the plane of its orbit; and still later the axis would swing over until it would lie in the plane; thus passing through every possible angle to this plane. But La Place reduced this motion and referred it to the law of gravity; and his computations have been since verified by other mathematicians. It is found that this change in the obliquity of the ecliptic is due to the change in the path of the earth's motion, due to the secular effect of the attractions of the other planets—sometimes pulling her off at an angle on one side of a fixed plane, and then on the other side of that plane. This fixed plane is one established by astronomers for the purpose of convenient reference for the orbits of all of the planets. It coincides nearly with the plane of Jupiter's orbit. The extreme swing of the earth's path from this plane is but 3°. At present the earth's orbit is about 1½° from the fixed plane. The obliquity will continue to diminish for ages; but the extreme change of the inclination cannot be more than 3° from its mean position.

Even if the third motion were a continuous rotation instead of an oscillation, as it is, it would fail to explain glaciation. The mean effect of a fixed amount of heat radiated to the earth from the sun is the greater the more uniform be the radiation to the surface; for this reason: The production of ice and snow is rapid during the intermission when the heat from the sun does not reach the earth. The greater the ice and snow, the greater will be the portion of the heat reflected back into space. This fact, generally ignored by writers on glaciation, is that where ice and snow are formed the cumulative effect of heat is at a maximum when the radiation to the surface is uniform. This condition would be most nearly approximated when the earth's axis is perpendicular to its orbit. So here M. Beziau's reasoning fails.

M. Beziau attributes the change in the obliquity of the ecliptic to a change in the position of the celestial equator, or the equinoctial,

and says, "this movement has been attributed to the ecliptic since its discovery without profound investigation, and on this hypothesis La Place and Le Verrier have rightly limited its extent. They have not properly considered the hypothesis in which the movement would belong to the equator. In that case they would be able to limit neither its extent nor duration."

It is a sufficient answer to this statement to say: If the obliquity were due to a change in the equator, a certain change in the declination of the stars would result, while the latitude of the stars would vary in a different manner. But if the obliquity be caused by the change in the earth's path (the ecliptic) the case would be reversed. Now it is the fact that the latitudes of the fixed stars so change as to be explained only by a change in the plane of the ecliptic itself. A slight knowledge of trigonometry and a moderate familiarity with the facts of practical astronomy would enlighten M. Beziau upon this phase of his theory.

M. Beziau's so-called law that "The planets turn about themselves on an ideal axis perpendicular to the plane of their orbit in an opposite direction from their movement around the sun and in a time equal to that of their revolution," is a law only so far as appearances go. To one located at the sun they would appear to so revolve, and this is for the same reason that one looking out of a car window forward and to the right sees the landscape rotate to the left, while if he looks forward and out the window at his left the landscape appears to rotate to the right.

M. Beziau's statement is very far from the facts when he says the rotation of the earth and moon about their common center of gravity is the cause of the "principal irregularities," "of the precession, the retrogression of the nodes of the moon, the nutation, the oscillation of the lunar orbit, libration, etc." The fact is that none of these motions can be so explained. The only effect of the rotation of the earth and moon about their common center of gravity is to make a slight sinuosity in the paths of their centers. In fact, the change can be called sinuosity only when compared to the curve of average position; the actual line of motion in each case being always concave toward the sun, the center of curvature being always in a direction toward the sun; the radius of curvature of the path of the moon's center being longer at new moon and shorter at full moon, and the radius of curvature of the path of the earth's center shorter at new moon and longer at full moon.

Libration is very easily explained, and is not a motion at all,

but an apparent motion merely. The motion of the moon on its axis is uniform, while the angular motion in its orbit is variable; so when the angular motion is greatest, the motion of the moon on its axis appears to be slightly retrograde, and *vice versa.* Libration is an apparent oscillatory swing of the face of the moon, giving us an opportunity of seeing about four sevenths of its surface in the course of the lunar month. Besides the libration of the moon in longitude explained above, there is a libration in latitude due to the inclination of her pole to her orbit, first nodding one pole toward the earth and then the other, behaving as the earth does to the sun and from a similar cause. Again, a daily libration is due to the rotation of the earth on its axis. If we see the full moon at six o'clock p. m., we see a slightly different surface twelve hours later, due to our changed relative position, 8000 miles at right angles to the line of sight.

Precession and nutation are firmly established on a mathematical basis and by observation as well. The former is caused by the attraction of the sun and moon on the protuberant mass at the equatorial regions because of the oblateness of the earth's form. This is not a direct effect, but a differential effect—the difference between the attraction for the side toward the attractive force and that for the side from it. There is no foundation for the statement that attractive forces attract the centers of mass only. Attraction affects every particle separately, the same as though they were in no way connected. Precession causes the pole of the earth to swing around the pole of the ecliptic once in 25,800 years.

Nutation has a similar cause in the moon, causing the pole of the earth's axis to describe a small circle in the heavens once in a lunar cycle of 18.6 years.

Likewise the gradual change of the angle of inclination of the moon's orbit to the ecliptic is due to planetary attraction, and is an oscillatory change, not a rotation.

To go deeply into the mathematics of these questions would require volumes. There are a large number of apparent irregularities which M. Beziau does not mention, the change in the longitude of perihelion, the rotation of the line of apsides, changes in eccentricity of the orbits of the planets, and other smaller secular changes.

It will be sufficient to say, in answer to his broad claims, that practically all these apparent inequalities have been computed mathematically and have been verified by observation; and what will be necessary for M. Beziau to do is to overturn the mathematics of La

Place and all the great mathematicians since his time, if he would convince the scientific world. His "third motion" is as inefficient as were the cycles and epicycles of the old Ptolemaic system of astronomy.

And still further, M. Beziau's third motion is impossible from a mechanical standpoint. It is a well-known fact of mechanics that a rotating body can have but one axis of rotation when rotating freely due to its own momentum. If the body be impressed with forces simultaneously or alternately tending to give it motion of rotation about more than one axis a single resultant axis of rotation is produced about which single axis it will continue to rotate until some other impressed force causes a new single resultant axis of rotation. The gyroscope in its various forms is a practical illustration of this fact of mechanics. A force brought to bear tangentially to a meridian line of the rotating body will cause the axis of the body to describe the surface of a double cone, the center of oscillation being the common apex, and this is just what happens to cause nutation and precession by action of the moon and sun. Much more is to be found in the article by M. Beziau which may be criticised from the standpoint of mathematics and physics, but it would be useless to go farther; enough has been said to show how utterly untenable is his theory.

CHARLES H. CHASE.

LANSING, MICH., Aug. 1, 1908.

ON HYPERSPACE.

To the Editor of The Monist:

Although the statement of your position with regard to the question of hyperspace, as given on page 471 of your current volume, is in the main highly satisfactory, it seems to leave something to be desired. When we are confronted by an apparent breach of the law of continuity, it would seem more logical to explain it as the result of a relative rather than an absolute limitation. If I walk three paces and bring up against a stone wall I say, "Here is an obstacle that I can not at present surmount;" I do not say, "This is the end of the universe; there are no more paces beyond." That we are three-dimensional beings living in a three-dimensional world is beyond doubt; but it would appear logical to regard this dimensional limitation not as inherent in the nature of things, but as due to